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ABSTRACT

This ERIC Digest presents highlights and recommendations from a working forum (Britton, Raizen, Kaser, and Porter, 2000) in which participants considered diversity and equity issues in mathematics and science education with special emphasis on research directions for the future. An overview of needed research, gender issues in mathematics, and the achievement gap in measures of quantitative reasoning are discussed. (KHR)

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The *No Child Left Behind Act* signed into law on January 8, 2002, places strong emphasis on state accountability for educational results and use of teaching methods that have been proven to work [see http://nclb.gov/next/overview/]. For teachers, these expectations highlight the importance of attending to issues of equity and diversity in mathematics classrooms, and the need to critically examine the existing research base both for evidence of best practices and gaps in our understanding that constitute areas of needed research. Educators and researchers need to know a lot more about how to address the increasingly acute diversity and equity issues in educating today's and tomorrow's children in mathematics.

Presented here are highlights and recommendations from a working forum (Britton, Raizen, Kaser, & Porter, 2000) where participants considered diversity and equity issues in mathematics and science education, with special emphasis on research directions for the future. Topics discussed at the forum covered a wide range of curricular and instructional equity issues in K-12 education, including the scaling up of successful programs. A number of clear research directions emerged from the forum.

Overview of Needed Research

Access to Courses and Teachers

- **Documenting in detail the inequitable access to high-level mathematics courses.** How does inequitable access affect specific population groups? Does the current emphasis on Advanced Placement courses increase inequities in college admission? What is the role of school counselors in exacerbating inequities in course-taking opportunity?
- **Research on incentives to recruit mathematics faculty members who mirror the diversity of the student body.** What are the barriers to getting experienced, diverse faculty for the students who most need them? How effective are the emerging incentives for recruiting teachers for schools serving these students and for retaining them?

Content, Instruction, and Assessment

- **Research on culturally appropriate and effective mathematics content.** How can curricula balance the culture that students bring to school with the world for which their education must prepare them?
- **Research on and development of instruction that will allow students from different cultural backgrounds to learn mathematics.** Does instruction need to be shaped to meet diverse cultural norms? What influences the development of mathematical reasoning in different population groups? Why do students from underrepresented groups who earn good grades in school mathematics fail to achieve comparable scores on mathematics tests?
- **Research on assessments that will allow students from diverse backgrounds to demonstrate what they know and can do in mathematics.** What is the interplay between students' socialization, cultures and languages, different forms of assessment, and the opportunity they have to demonstrate their competence in mathematics? How can large-scale assessments be monitored to ensure their alignment with standards? What additional measures need to be developed to facilitate the use of multiple measures in assessing what diverse students know and can do in mathematics?

Understanding and Scaling up Effective Programs

- **Compiling programs that successfully address current inequities and research on effective replication on a broad scale.** What are the successful programs that should be scaled up? What are the lessons learned? What are effective and ineffective strategies for increasing access for and achievement of diverse student groups? How can reforms harness the system's resources to scale up from a few successful sites? What are the roles of parents and communities?
- **Improved evaluation of intervention programs.** Do evaluations document the relationships between student achievement and the system's processes of accountability and resource allocation to needy schools? Do evaluations consider unintended consequences that can thwart a program's success? Are there longitudinal evaluations in place that can determine more definitively the effects of reform initiatives on underrepresented groups?

Teacher Preparation, Induction, and Professional Development

- **Research on effective preparation and support programs for teachers to deal effectively with the needs of the diverse learners in their classrooms.** How can teaching for diversity be infused throughout teacher education as the essence rather than relegating equity and diversity issues to a separate, single problematic topic? What teaching strategies do preservice and in-service teachers need to know and practice to deal effectively with the learning needs in their classrooms?
- **Research on the support needed for beginning teachers.** How can beginning teachers be supported in learning how to address diversity and equity issues? How can we provide effective experiences in an efficient way that will help beginning teachers successfully teach mathematics and science to all their students?

Better Research Methods and Dissemination

- **Disaggregation of data to more accurately reveal possible inequities in access and achievement.** How do diverse groups of learners respond to various interventions? How can achievement gaps be described more accurately in terms of diverse student populations?
- **Improving the pool of researchers to more closely reflect the diversity of the K-12 student body.** Are the voices of females, underrepresented groups, language and culturally diverse groups heard in the framing of research questions, data gathering, and analyses on mathematics learning? How can information technology be used to include these groups in research on equity and diversity issues?
- **Improved dissemination of existing research on equity and diversity issues in mathematics education.** How can existing knowledge be shared more widely? How can it be translated and packaged so that people – community leaders, administrators, leaders in mathematics education, teachers – can use it?

In responding to these priorities for research, Judith Sunley noted the potential role of information technologies in overcoming some of the current difficulties in addressing the identified issues:

> One of the real problems of addressing equal opportunity, equity, and diversity is that many communities of underrepresented groups are actually quite isolated from the mainstream of science and engineering, both in research and education. If we can take advantage of the current boom in information technology to make those connections and break some of the isolation, we have an opportunity to bring people in.

Gender and Mathematics

Research over the past three decades has made significant contributions to defining and understanding the complexity of issues dealing with gender and mathematics (Fennema, 2000). That differences exist in the learning of mathematics seems clear, although many scholars believe either that learning differences are diminishing or that, if any differences do exist, they are unimportant. However, the more tests measure true mathematical problem solving, the more apt one is to find gender differences in mathematical learning that favors males at

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almost any age. Females also appear to hold more negative values about mathematics and their relationship to mathematics than do males, but there is some evidence that these differences are decreasing. These simplistic statements, however, hide more than they reveal. What mathematics was being measured in tests where gender differences have been studied? How was the information about values obtained? Were females' voices a part of the data-gathering procedures? Too often the research that has reported gender differences has provided an incomplete picture at best and has only helped to perpetuate the belief that females are somehow inadequate in relation to mathematics.

What Do I Wish to Know?

Even if we assume there are gender differences in mathematics, we do not have clear direction on what to do in order to achieve educational equity. One major reform recommendation has to do with encouraging students to communicate their mathematical thinking by presenting their ideas and convincing peers of their correctness by arguing and questioning. It is widely believed that those who enter into this kind of debate will learn better, but will girls enter into this kind of communication as willingly as do boys?

Another reform recommendation has to do with the use of technology in the classroom. It is clear that currently boys have more experiences with technological toys than do girls. Does this reflect interest or ability with technology? How should teachers take this into consideration as they plan their instruction?

Another recommendation is that mathematics should be situated in problem-solving contexts that are socially relevant. Unfortunately, many textbooks and teachers are more aware of contexts that are from male-dominated fields such as parabolic equations for projectiles or sports statistics. Can mathematics be situated equally in female-dominated contexts, and, if so, will boys willingly participate in such problems? Should classrooms be competitively organized or organized around cooperative activities? Some studies have suggested that boys learn better in a competitive situation, while girls learn better in a cooperative situation. Is this always true? Is the solution to have single-sex classrooms?

What Do I Wish Was Known?

Gender as a critical variable must enter the mainstream of mathematics education research. It is insufficient to say and to believe that the study of gender differences can be left to those who are specifically interested in gender. Specifically, we need to continue the study of gender in relation to mental processing of both students and teachers. We probably cannot study how the gender of the teacher influences instruction because of the limitations imposed by the relatively low number of male teachers. However, we can study teachers' beliefs and knowledge about girls and boys and the impact that teachers' cognition has on instructional decisions for both girls and boys.

Classrooms that reflect the various demands for reform are becoming more prevalent. But are they equally effective for boys and girls? The learning that results from these reformed classrooms needs to be monitored carefully. Perhaps as we do this, we will begin to develop an image of what equitable mathematics education is.

The Achievement Gap in Measures of Quantitative Reasoning

We have seen that students who have the requisite declarative knowledge to solve a class of quantitative reasoning problems nevertheless fail to use that knowledge when it is required (Bond, 2000). Additional research is needed to describe more completely the nature and structure of the mathematical knowledge that students with the "good grades/low test scores" achievement pattern have. More research is also needed on the features of quantitative reasoning problems that make it likely that students who have the required knowledge will correctly solve them. Perhaps the single biggest instructional challenge in all of high school mathematics is the difficulty teachers have in moving students from being able to solve well-structured problems to being able to solve verbally presented tasks (i.e., "word problems"). The most pressing immediate research imperative, though, is of a more ethnographic nature.

What antecedent instructional conditions facilitate or frustrate the development of proficiency in quantitative problem solving? Two general categories of studies come to mind: studies of instruction taking place in actual classrooms and studies of student non-classroom engagement and time spent on things academic. What constitutes "quality teaching" in elementary, middle, and high school mathematics? What does the teacher assume about the state of knowledge of his or her students? Is instruction appropriately paced? Does the teacher sequence hierarchically ordered concepts in a rational and coherent way? How does he or she respond to individual differences in readiness? What kinds of assignments does he or she give the class, and what is the nature and quality of his or her individual student feedback? How does the teacher monitor and assess student progress, and what level of student proficiency do his or her grades reflect? If we are to relate student achievement to teaching expertise in any defensible way, this level of specificity is essential. A well-designed ethnographic study of actual classrooms would be an enormous contribution to our understanding.

Issues of readiness and "social promotion" must also be systematically studied. Many students, especially those in overcrowded urban schools where many math teachers are certified in areas other than math, may advance through the mathematics sequence with acceptable grades but fundamentally unprepared for the next level of math instruction.

Research is also needed on exactly how students spend their non-classroom hours. Other things being equal, can individual differences in proficiency be traced systematically to the amount and quality of non-classroom time that students are engaged in relevant tasks? Student self-reports are often unreliable and generally insufficient. Observational studies of non-classroom activities, while expensive, are not impossible.

Finally, it should be noted that social and psychological factors involved in performance on cognitive measures are clearly important. Claude Steele's highly original and insightful investigations into the phenomenon of "stereotype threat" are a case in point (Steele 1997). He convincingly demonstrated that individuals who are the object of a negative stereotype (as African American students are with respect to measures of intelligence and scholastic ability) tend to so internalize the stereotype that it adversely affects their performance on such measures. We need to know how pervasiveness this phenomenon is and to devise effective ways to counter its potentially harmful effects on student academic growth

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